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THE FORMULATION AND EVALUATION
OF
A UNIT OF LACROSSE AND INSTRUCTIONAL ACTIVITIES

Submitted by

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(B. S. in Ed., Teacher for State Teachers College, 1939)
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CHAPTER I

THE SCOPE AND PURPOSE OF THIS SERVICE PAPER

The problem. The writer has attempted to develop and teach a unit in magnetism and introductory electricity applying the basic principles set forth by Doctor Roy O. Billett in his book Fundamentals of Secondary-School Teaching and in his course The Unit Method in the Secondary-School, as presented at the Boston University School of Education. The terminology used in this paper is the terminology used in Fundamentals of Secondary-School Teaching.

Motivation. Those who have been teaching physics and the sciences for the past several years are aware, of late, that our field is gaining more popularity and publicity via the press and radio. This added attention is probably due to the war and the many recent developments in the field of the physical sciences. One might expect that this new interest in this field would be evidenced by increased enrollment in high school science courses. However, such is not the case. In fact science courses, including physics, which is my primary concern in this paper, have shown decreasing enrollment.^{1/}

In view of the above, the writer has been somewhat

^{1/}Roy O. Billett, Fundamentals of Secondary-School Teaching, p. 258

concerned and has concluded that one of the main reasons for the dearth of science and physics pupils is the method of presentation of the subject matter. Purely academic teaching of the various phases of high school physics can be a monotonous drudgery for both the instructor and the pupils. Factual information and the use of rote memory is not desirable.

The purpose. The writer hopes that the unit developed in this paper will produce an increment of educative growth, and that the pupils will be aware of progress made. If successful in this attempt, some small progress will have been made in outmoding older and inadequate methods of presentation of science subject matter.

The task of building a unit, such as this, is substantially one for the individual teacher: to design a unit which does not require an excessively long time to teach, and which can be fitted into a course with a minimum of teacher and pupil confusion and a maximum of usable content matter.^{1/}

It is hoped that concepts, skills, ideals, attitudes, and appreciations will be forth-coming to make this phase of physics flexible enough to care for the differing aptitudes, abilities, interest, aims, and needs of the pupils taking the course.

^{1/}Thirty-first Yearbook, National Society for the Study of Education, p. 255

The Local Situation. This unit was developed and taught at the Haverhill High School located in Haverhill, Massachusetts. This is a school of some fifteen hundred pupils. Those enrolled in physics courses are college-preparatory pupils.

The Pupils to be Taught. The A section physics class was selected for the teaching of this unit, as it was felt that this was a good representative group of college-preparatory pupils. The chart of pupil statistics found on the following page will supplement this assumption. The designation A does not necessarily mean that they are the best students. Our school makes an attempt at homogeneous grouping but there is no clear-cut line of demarcation.

This is a mixed class of twenty-five pupils. Alphabetical representation will be given to these pupils as found in Tables I and II on page four and sixty-two respectively. It is hoped that these tables will make the reader more familiar with this particular group of pupils.

The other two sections of College-Physics pupils, designated as B and C by our administration, also measure high in intelligence quotient as might be expected since the college-preparatory sections consist of a select group.

TABLE I

PUPIL STATISTICS. SEX, CHRONOLOGICAL AND MENTAL AGES, INTELLIGENCE QUOTIENTS, AND AVERAGE MARKS OF PUPILS PARTICIPATING IN THIS STUDY

PUPIL	SEX	Chronological Age	Mental Age	Intelligence Quotient	Numerical average in subject matter as of the presentation of this unit
A	F	16-5	18-1	110	80
B	M	16-5	18	109	85
C	M	16-8	19-4	116	75
D	M	17-11	19-1	120	80
E	M	16-6	18-7	113	80
F	M	17-11	18-4	110	80
G	M	16-2	16-4	101	65
H	F	16-7	22-0	127	85
I	M	17-10	17-1	103	75
J	F	16-2	19-0	122	85
K	F	16-4	21-2	131	85
L	M	15-11	17-7	111	70
M	F	16-0	18-6	110	75
N	M	17-6	17-4	112	80
O	M	16-1	19-2	120	75
P	M	17-8	22-4	147	95
Q	M	15-2	20-7	125	85
R	F	16-3	22-7	141	90
S	M	16-2	16	99	65
T	M	16-8	16-2	98	75
U	F	17-0	17-6	112	80
V	F	17-11	18-0	112	75
W	M	17-10	19-2	121	70
X	M	16-6	17-2	104	60
Y	M	16	22	122	80

Space provisions. The physics room is a combination laboratory and class-room. Figure I below shows that there are six movable tables with individual stools for the pupils. Although not clearly indicated in this figure, there are continuous benches for individual work on two sides of the room. These benches plus a continuous shelf running above them also provide adequate space for reference materials. Thirty pupils may be accommodated in this room.



Figure I. Physics classroom-laboratory as viewed from the instructor's desk.

An adequate demonstration table, which has running water and electrical and gas outlets, is located at the front of the room. The instructor's desk is adjacent to this demonstration table. (See Figure II)



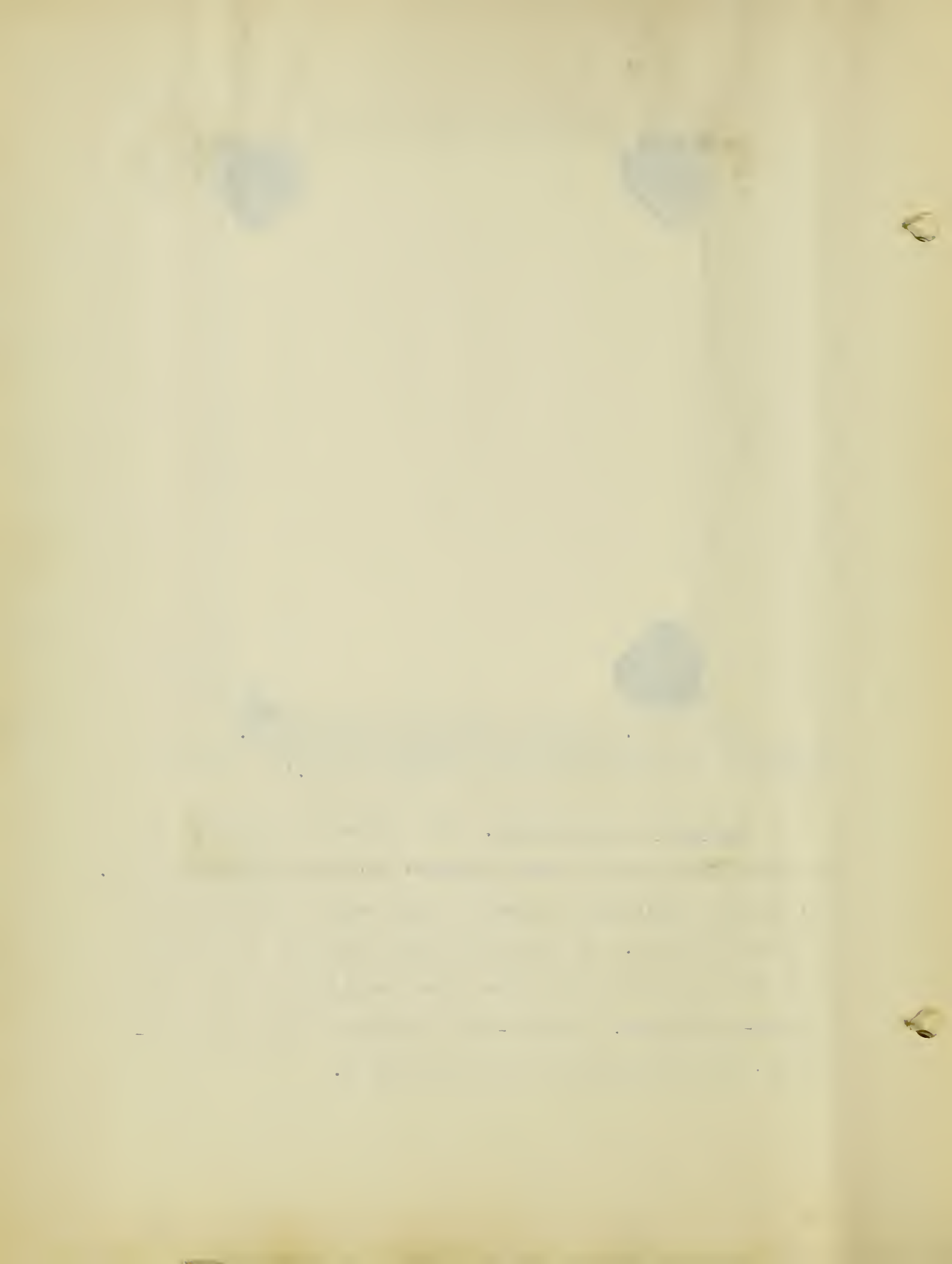
Figure II. Physics classroom-laboratory as viewed from the rear of the room.

Figure III shows the office and supply room which is adjacent to this classroom-laboratory. The proximity of this supply room makes the equipment easily accessible.



Figure III. Physics office and supply room.
(Apologies are offered for the presence of "Susie" who was waiting to be demonstrated to a biology class.)

Equipment and Supplies. The equipment is carefully arranged and labeled in the equipment room mentioned on page 6. All physical equipment needed for this unit is available and in good condition. In addition we are fortunate in having a steel filing cabinet and audio visual equipment in the form of a radio-phonograph, a thirty-five millimeter film strip projector, and a sixteen millimeter projector.



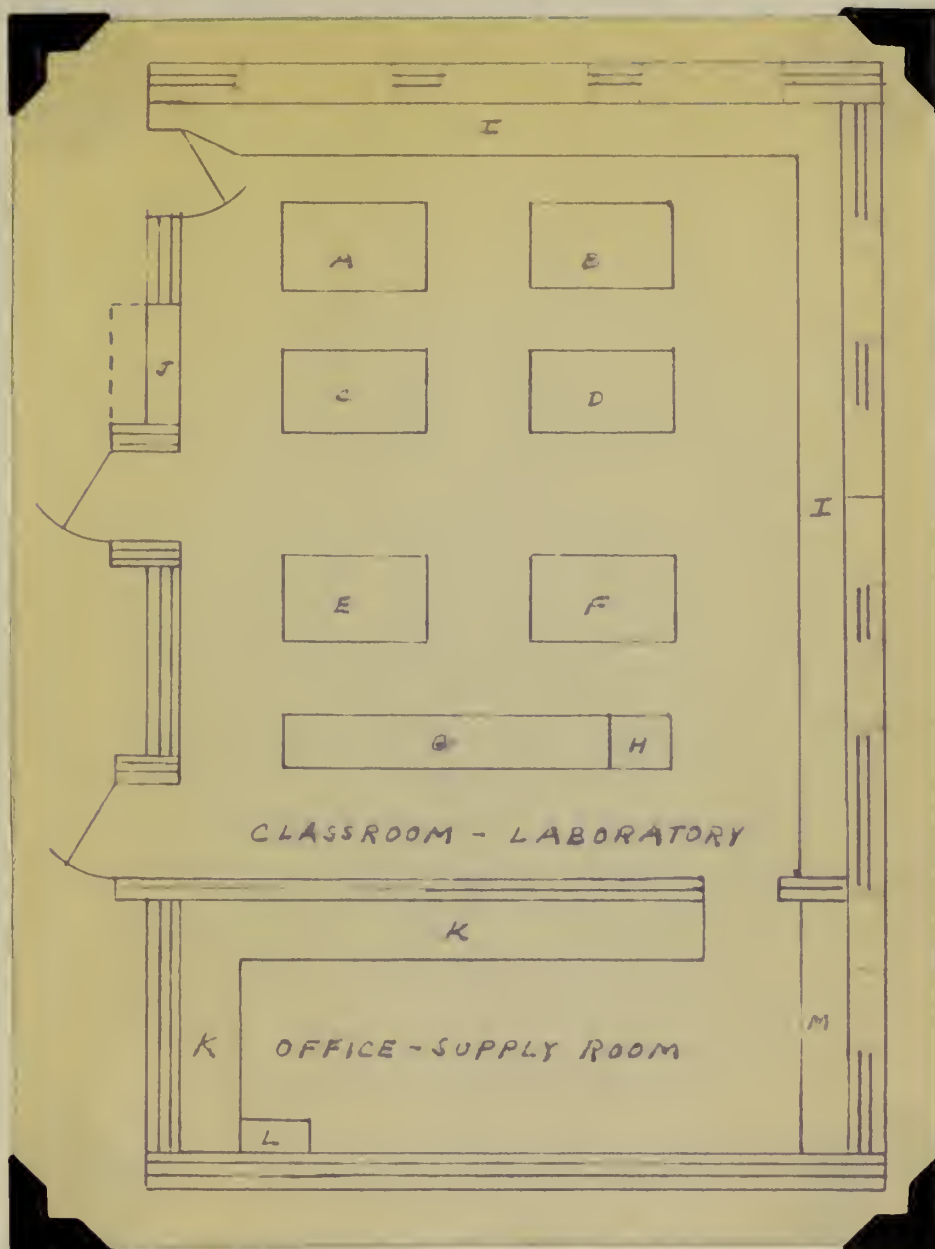


Figure IV. Physics classroom and office (17' x 22')
Key - Scale 1/8" = 1' - 0"

- A - F - Pupils' tables (4' x 6')
- G - Demonstration table (3' x 6')
- H & L - Teacher's desks
- J - Teacher's bench
- I & K - Supply closets

Much of the data on this group will be taken from the cumulative office records. The test found in Chapter II will be used as a pretest and a final test. The scores on these tests and the gain will be found in Table II, page Fifty-six of Chapter III.

CHAPTER II

A UNIT ON MAGNETISM AND ELEMENTARY ELECTRICITY
FOR ELEVENTH-GRADE STUDENTS

The unit.^{1/} In Magnesia, Asia Minor, beds of iron ore are found which have the property of attracting bits of iron, nickel, cobalt, or steel. This ore was discovered by the Greeks, and is called Magnetite. This black iron ore is also found in the Adirondacks and in certain other localities. Pieces of this ore are known as natural magnets.

Magnets are closely associated with electricity in many respects. The term magneto-electric pertains to, or is characterized by, electricity developed by magnets, as in a machine using permanent magnets.

The Delimitation of the Unit.^{2/} (1) When an elongated piece of magnetite is suspended by means of a thread so that it will be free to swing or turn in any direction, the magnetite will turn around until it assumes a direction that is nearly north and south.

(2) As early as the twelfth century, magnetite or lode stone (leading stones) were used to indicate direction, much as magnetic compasses are now used.

(3) It is believed that even before the Christian era, the ancients had learned how to magnetize iron by rubbing it on a piece of lode stone.

^{1/} Millett, op. cit. p. 505
^{2/} Ibid. p. 506

(4) The chemical symbol for magnetite or lode stone is $(Fe\ O.\ Fe_2\ O_3)$

(5) The compass, which has a magnetized steel needle, is most valuable to mariners, aviators, explorers, and surveyors.

(6) It is quite possible that the Chinese had compasses many years before the Europeans re-invented them.

(7) A magnet has spots, known as poles, where the attraction is greatest.

(8) These spots or poles (2) are referred to as the North and South poles.

(9) The earth acts like a large magnet. Its magnetic South pole is near the geographic North pole.

(10) Declination is the number of degrees by which the North pole of a compass needle points away from the geographic North.

(11) In early times, it was thought that declination was everywhere the same. Columbus, when on his way to America in 1492, discovered a place, near the Azores, of no declination.

(12) The positions of the earth's magnetic poles are known to be changing from year to year.

(13) A magnet can be broken into a great number of smaller magnets.

(14) Any magnet loses a part or all of its power if it is heated red-hot, jarred, hammered, or twisted.

(15) The theory of magnetism was suggested by a Frenchman, Ampere, and elaborated by a German, Weber, and an Englishman, Tving.

(16) Our modern atomic theory assumes that within the atom, there are little circular currents of electricity (electrons) and that these produce the atomic magnets.

(17) William Gilbert, the physician of Queen Elizabeth, was the first Englishman to use experimental methods in order to test certain theories. As early as 1600 A.D. he published "De Magnete" a work containing many interesting facts that he had learned in experimenting with magnets.

(18) Michael Faraday was the first investigator to see that a true understanding of the action of magnets could be obtained only by studying the space around them as well as the magnets themselves.

(19) In 1819, a Dane, named Oersted discovered that if an electric current is passed over or under a magnetic needle, the needle tends to set itself at right angles to the current. This was a most important discovery because it showed for the first time that there is a relationship between electricity and magnetism.

(20) For the purpose of determining the direction of the lines of force produced by a current, we assume that the current direction is from the plus (+) terminal of the battery to the minus (-).

(21) The actual direction of an electric current is from minus (-) to plus (+).

(22) Each turn of wire about an electro-magnet produces its own lines of force, hence the greater number of turns, the stronger the magnet.

(23) The lines of force are caused by the flow of the current.

(24) The strength of an electric current is expressed in amperes.

(25) The product of the number of amperes multiplied by the number of turns is called ampere-turns and this determines the strength of the magnet.

(26) An iron core in a solenoid concentrates lines of force that would otherwise leak out between the turns.

(27) The strength of an electro-magnet is proportional to the number of ampere-turns and to the permeability of the iron core.

(28) In addition to the magnetic and geographic poles another pole should be given consideration. This is the weather pole which is the Greenland ice cap and which is under study of a competent group of scientists at the present time.

(29) When two different bodies are brought together and then separated, they are found to be electrified. The electric charge on one is positive, that on the other is negative.

(30) Like charges repel; unlike charges attract.

Electric charges can be retained by insulators or insulated bodies.

(31) An electron is a particle of negative electricity $1/800$ the mass of hydrogen atom.

(32) Atoms of matter are composed of electrons surrounding a nucleus of positive electricity.

(33) A body that is positively charged is one that has lost electrons from some of its atoms.

(34) By induction an insulated body has its electrons temporarily displaced when a charged body approaches.

(35) During electrification, electrons leave one body, making it positive, and pass to another body, charging it negatively.

(36) An electric current in a wire consists of a stream of electrons driven through the wire from negative to positive by electromotive force. (emf)

(37) A difference in charge between two bodies causes an electrical pressure. Electrical pressure is called electromotive force and is measured in units called volts.

(38) Resistance is measured by various methods of comparison or calculation. One method is to measure the current through the circuit and to measure the difference in potential of the two ends of the circuit. The volt-meter reading divided by the ammeter reading gives the resistance. (Ohms Law)

List of Probable Indirect and Incidental Learning Products.^{1/}

A. Indirect

1. An appreciation that what now seems to be simple, basic laws had to be discovered, worked out and proven many years ago.

2. As a student follows an orderly procedure, he acquires a scientific attitude and method.

3. An appreciation of the many different sources of material that may supplement the text-book, such as magazines, newspapers, motion pictures, and radio, and how the student benefits from this diversified source of material.

B. Incidental

1. A more useful and specific knowledge of man's efforts to utilize nature's gifts to their full extent.

2. A realization that there are still many theories in the field of science, theories which must be accepted until they can be proved or disproved.

^{1/}Alcott, op. cit. p. 737

List of Materials and References for Teacher's Use Only ^{1/}

1. Billett, Roy O. Fundamentals of Secondary School Teaching. Boston: Houghton Mifflin Company, 1940.
2. Billett, Roy O. The Administration of Grouping in Secondary Schools, Thirty-Fifth Yearbook of the National Society for the Study of Education, Part I. Bloomington, Illinois: Public School Publishing Company, 1936.
3. Brown, Murrett H. The Development of a course in the Physical Sciences for the Senior High School of the Lincoln School of Teachers College. New York: Bureau of Publications, Teachers' College, Columbia University, 1930.
4. Hunter, George W. Science Teaching at Junior-Senior High School Levels. New York: American Book Company, 1934.
5. Prester, C. E. The High School Science Teacher and His Work. New York: McGraw-Hill Book Company, 1936.
6. Progressive Education Association Commission of Secondary School Curriculum, Science in General Education. New York: D. Appleton Century Company, 1933.
7. The University of Chicago Laboratory Schools, Science Instruction in Elementary and High School Grades. Chicago: The University of Chicago Press, 1933.

^{1/} Billett, op. cit. p. 569

THE UNIT ASSIGNMENT ^{1/}

Introductory Activities. ^{2/}

A. The study of magnetism and introductory electricity will take three weeks of time. Many students of physics consider this to be the most interesting and useful phase of this subject.

B. An introductory talk, demonstrations, and discussion centering around the following:

1. What causes or produces electricity?
2. What does electricity consist of?
3. What are the characteristics of electricity?
4. What is the difference between positive and negative electricity, and statical and dynamical electricity?
5. What are magnets? Where are magnets found?
6. In what way or ways are magnetism and electricity related?
7. The above questions are for the purpose of stimulating interest and motivating the class in their study of this topic.
8. It might be wise to also ask members of the class for questions they might have and to discuss these briefly.

^{1/}Billiett, op. cit. p. 506
^{2/}Ibid. p. 508

C. Inform the class that they are about to see a sixteen-millimeter picture which will cover much of the material that was discussed. Distribute a mimeographed list of the previous six questions which they will be asked to answer. Ask them to also list any other questions that arise while viewing this film.

It is suggested that this introductory film should be, What is Electricity, which is a free film, courtesy of the Westinghouse Electric Corporation, and may be obtained from the distributor, Modern Talking Picture Service, 9 Rockefeller Plaza, New York 20, New York. This picture requires twenty minutes showing time.

The following four pages of this paper contains a list of auditory-visual aids which may supplement or take the place of the suggested film at the discretion of the reader, or possible user of this unit.

AUDITORY VISUAL AIDS

The following films may be obtained from Castle Films,
60 Rockefeller Plaza, New York 2, New York:

1. ROTATING MAGNETIC FIELDS

OE 384 12 min. \$22.50

Explains a rotating magnetic field pattern; traces the three-phase winding in a demonstration stator; shows the factors that cause rotation of the magnetic field, and the construction of polyphase motors.

(Accompanying Filmstrip \$1.00)

2. DIRECT CURRENT CONTROLLERS

OE 328 15 min. \$27.15

Shows shunt motors and direct current controllers in operation and by animation, a direct current faceplate controller connected to a shunt motor.

(Accompanying Filmstrip \$1.00)

3. THREE-PHASE MOTOR

Part 1: Preparing to Rewind

OE 385 17 min. \$28.50

Shows how to interpret and record nameplate data of a three-phase motor; identify the line leads and finish leads; remove coils and determine coil span; use a coil winding machine; and end-tape machine wound coils.

(Accompanying Filmstrip \$1.00)

4. THREE-MOTOR

Part 11: Rewinding

OE 326 17 min. \$29.29

Shows how to insert rush coils; insert separators or "willies"; fold, trim, and wedge slot insulation around windings; insert phase insulation; and make a delta connection.

(Accompanying Filmstrip \$1.00)

5. REPULSION-INDUCTION MOTOR

General Overhaul

OE 327 25 min. \$27.32

Shows how to check a repulsion-induction motor for electrical and mechanical faults; dismantle a repulsion-induction motor; remove a damaged coil and wind and insulate a new coil; and assemble and lubricate a repulsion-induction motor.

(Accompanying Filmstrip \$1.00)

The following films may be obtained from Ideal Pictures Corporation, 40 Melrose Street, Boston 16, Massachusetts.

1. ELECTRODYNAMICS 10 min. J-3-C

Animated and normal photography treat; Galvani's discovery of current electricity; magnetic field about a live wire; magnetic field of a coil; electromagnets; Rowland's experiment; magnetic hypothesis; regalescence; magnetic induction; A.C. and D.C. generators; current induction; and transformers. Rental: \$5.00.

2. ELECTRON, THE -- AN INTRODUCTION. 10 min. S-C-A

Explains the nature of electrons, electron flow in solid conductors, electromotive force, control of electron flow, types of electron flow, electron flow and magnetic fields, and induced electron flow. Rental: \$1.05.

3. ELECTRONS. 10 min. S-C

Normal photography and animation explain the following phenomena and principles; Faraday's laws; valence; Millikan's oil drop experiment; the principles of vacuum tubes; Edison effect; photoelectric cells; reproducing sound on film; and the determination of the electron's mass. Rental: \$2.00.

4. ELECTROSTATICS. 10 min. J-S-C

Photography and animated drawings describe the production of negative and positive electrification on the basis of the electron theory, explain the movement of the electrons in the electroscope, the operation of a static machine, condensers, lightning and lightning rods. Rental: \$2.00.

5. ELEMENTS OF ELECTRICAL CIRCUITS. 10 min. S-C

Animated drawings clarify the nature of electron flow, factors affecting resistance, conductors, insulators, the ohm, current and ampere, electromotive force and the volt and in conclusion Ohm's law with type problems. Rental: \$2.00.

CORE ACTIVITIES ^{1/}A. Introductory Explanation.

1. Look over the mimeographed material which you have just received.
2. Examine the various reference books which are now on the reference shelf.
3. When you write up an experiment, and you may do so at any time, follow your usual laboratory procedure. A copy of the form used in recording our laboratory work will be found on the following page.
4. You may submit written work at any time. All work must be completed by three weeks from today, however.
5. Feel free to call on me at any time if any problems arise.
6. You may follow your usual laboratory procedure working in groups or you may work alone. (It is the feeling of the writer that pupils working in groups of two or three profit more in laboratory work than by working individually. This might be called a limited "pooling and sharing of experience phase.")
7. When you complete the core activities please consult the desk and examine the optional activities which will be found in the card file. A list and a brief description of these activities will be found on the bulletin board. If you find an activity that appeals to you, follow it through after securing my approval.

^{1/}Billett, op. cit. p. 507-508

9. The numbers following the statements in the core activities refer to a special book on your reading and reference list. For example, the numbers 4: 5-8, mean reference book number four, pages five to eight.

Some statements, marked with an asterisk (*) will not have such a number. In such a case, you are expected to search through the reference books to locate the desired material.

B. Questions, Problems, and Other Suggested Activities.

1. Distinguish between natural magnets, permanent magnets, and temporary magnets (1: 330, 331. 9: 399. 7: 493). ✓

2. Distinguish between repulsion and attraction (1: 332. 6: 475. 3: 146). ✓

3. Where are the places in our country which have the most and the least declination (1: 334. 4: 255. 11: 137. 3: 561)?

4. Make a complete diagram showing how the earth acts as a huge, round magnet (1: 334. 4: 255. 10: 504. 11: 135. 5: 290).

5. In finding the magnetic north in a certain laboratory, a good compass was used with great care, but the results were many degrees out of the way. What was the probable reason? No reference--applied reasoning.

6. What are isogonic lines (8: 563. 10: 426. 7: 403)?

7. Write a brief report on Michael Faraday indicating his contributions in the field of magnetism and electricity (1: 337. 7: 421. 6: 552).

8. Make a diagram indicating and explaining magnetic induction (1: 339. 6: 551. 5: 324). ✓

9. Distinguish between permeability and reluctance (1: 340. 5: 322. 6: 430).

10. List several uses of permanent magnets (1: 342. 6: 432. 11: 122).

11. With the aid of a diagram explain the theory of magnetism (1: 342. 11: 126, 127. 6: 550). ✓

12. Can you describe a device that serves to keep the compass box horizontal during the rolling of a ship (8: 572. 6: 164. 10: 482. 7: 156)?

13. Why is the gyro compass used on ships and many ocean liners? On what principle does it work? No reference--thought question--use reference books.

14. How can the compass on an iron ship be "compensated" for the induced magnetism in the ship (7: 152. 2: 553. 10: 496)?

15. How does electrification differ from magnetism (1: 346. 9: 572. 6: 404)? ✓

16. What are some of the properties of magnetic lines of force (6: 479. 2: 551. 1: 338)? ✓

17. Why does the horse-shoe shaped magnet have an advantage over the bar-shaped magnet (8: 556. 7: 409. 4: 249, 250)?

18. What is the electron theory of magnetism and electricity (1: 252. 7: 412. 11: 144. 4: 262)?

19. What are isogonic lines? Why are they used (7: 402. 9: 562. 5: 221)?

20. What materials are dia-magnetic (non magnetic) (7: 404. 5: 222)?

21. List three properties of magnetic lines of force (7: 408. 4: 249. 3: 472. 5: 227).

22. If the balance wheel of a watch becomes magnetized, the watch fails to keep good time. How may the works of a watch be protected against magnetization? *

23. In an unsurveyed territory how may one find true north? *

24. In order to pick up magnetic materials with a horse-shoe shaped magnet, the armature of the magnet must first be removed. Explain. *

25. A ship made almost entirely of wood was sent out by the Carnegie Institute to make magnetic surveys. What are the advantages of such a ship, and why must such surveys be made from time to time? *

26. How may electricity be produced by friction (7: 415)?

27. What is the theory of electricity? Make a diagram of a sodium and a chlorine atom for illustration (7: 417, 418). ✓

28. Draw a diagram of a condenser and explain how it functions (7: 426).

29. Make a chart comparing magnetism and electricity (7: 428).

30. Explain how current electricity differs from static electricity (7: 437). ✓

31. Prepare a five-to-ten minute talk for presentation to the class on how the dry-cell is constructed. Have a dry-cell which you can disassemble for the purpose of illustration (7: 438).

32. What are the values of electrical units? Acquaint yourself with sample problems illustrating the various laws of electricity (7: 440-445). ✓

33. Diagram and explain a telegraph-circuit. If interested, obtain the material from the instructor and wire one up. Notice the various adjustments (7: 457).

34. Look over the material given on magnetism and electricity in one or more of the reference books. What laws or types of mathematics are required in this work with which you are familiar? Is there any type of mathematics required that you are not familiar with? Write a brief paper as to your findings. If possible, check with a teacher of mathematics as to your findings, and indicate the result of the discussion in your paper.

Optional Related Activities.

1. Collect as much information as possible on magnetism and electricity from magazine and newspaper articles or from any other sources you may discover. Organize the same and be prepared to make a special oral report to the class. (ten minute report).

2. Make a chart of the United States and locate the isogonic lines of force.

3. Examine experiments number thirty-seven, forty-three, and forty-seven as found in the "Laboratory Manual" by E. Henry Black. These are basic and worthwhile experiments pertaining to our topic. If one or more of these experiments appeal to you, proceed with the experiment or experiments and write the same up in your usual manner or the required form.

4. Write a complete history of magnetism. (Gather as much information as possible on the subject of magnetism, from as many sources as possible, and organize the same in chronological order).

5. Check with some official that you may know who works in one of the local industrial plants. Prepare a group of questions relative to the importance and use of electricity in this particular plant, and discuss the same with this person. Write a brief report of your findings.

6. Electrical and magnetic phenomena are usually quite interesting and amazing to students of physics. It is suggested that you look at exercises eighty-nine and ninety-one as found in Workbook in Physics by Fuller, Brownlee, and Baker -- Allyn and Bacon. If these activities appeal to you, follow the instructions and write the results of your findings on your laboratory report forms.

7. If one is to properly understand electricity in all of its many aspects, one must be familiar with the lines of force around a conductor. Examine the various reference material and see what you may find on this topic. Make a brief written report, including diagrams as to your findings.

If your interest is really aroused after proceeding this far, you may wish to complete exercise number sixty-eight as found in "Workbook in Physics" by Fuller, Brownlee, and Baker -- Allyn and Bacon. If you do select this activity, report your findings on the laboratory report form.

8. In order to fly from one place to another by dead reckoning, a pilot or a navigator must be able to do the following: (1) Correct true course to find the magnetic course.

(2) Chart a true course for flying from one location to another.

(3) Correct magnetic course to find the compass course.

(4) Correct the compass course to get the compass heading.

See if you can obtain the information as to how these may be done. It is suggested that you check with the instructor, any pilot or navigator that you may know or the various reference books that are available.

Write a written report or offer to make a brief talk to the class on this subject.

9. Examine the electrical wiring in your home. Write a brief description as to how your home receives electricity and how the current runs through your house.

10. Obtain the material necessary for the installation of an electrical outlet plug. Secure a piece of pine board from the manual arts instructor and proceed to install the same in the board. When completed be prepared to demonstrate the same to the class.

11. Make a list of all the electrical appliances in your home. Try to determine when each appliance first appeared on the market. Check with your grandparents or older people for approximate dates.

12. Ask the instructor if you may disassemble the vacuum cleaner in the equipment room. See if you can reassemble the same so that it will run properly.

13. Have a talk with an automobile mechanic or battery man as to the construction of a storage battery. Plan

a ten minute talk to the class on your findings. Better still ask the man if he will speak to the class on this topic.

14. Talk with your family doctor, if possible, and determine just how magnetism and electricity are used to great advantage in the medical profession. Discuss your findings with the instructor or write a brief report of the same.

15. Jacob Rabinow of the National Bureau of Standards has invented a new magnetic clutch for automobiles. Try to find out how this clutch works. Write a brief report. Electromagnetic fluid brakes can be made to operate on this same principle.

16. The term cyclotron is relatively new and yet universally known to the world as a giant electrical monster used to smash atoms and to manufacture radio-active isotopes. The largest and the most powerful magnets in the world are used in these devices. Obtain further information on the use of magnets in cyclotrons by writing to the science departments at the University of California and Columbia University. Write a report of your findings.

17. Secure the material necessary to wire an ordinary house-bell or chime from the instructor. Mount this material on a panel board and wire in such a manner that the bell will be activated by either of two push-button switches. Be prepared to demonstrate this equipment to the class.

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Student's Name

INSTRUCTIONS TO STUDENTS TAKING THIS EXAMINATION

The examination you are about to take on the subjects of magnetism and electricity and their relationship to one another will be completed in one period.

1. This examination consists of five sections, A. B. C. D. E. -- Read the instructions carefully for each section and proceed at your own speed.

2. Do not spend too much time on any one item. Return to such items when you complete the examination, if time allows.

3. Write all answers on the examination paper in the indicated space.

4. When you complete this examination, put your pencil down and turn the paper face down.

	A	B	C	D	E	
						Maximum Total
Maximum actual	20	15	20	10	33	98 Total score

PART A

Think of the word or group of words necessary to complete the meaning of each of the following statements. Write this word or group in the blank space at the right having the same number as the blank space in the statement.

1. In magnetism like poles (1) and unlike 1. poles (2). 2.

2. Repulsion and attraction between two magnets are directly proportional to the product of the (3) of the poles and inversely proportional 3. to the square of the (4) between the poles. 4.

3. The vertical mark on the glass of the window through which the pilot reads the scale of a magnetic compass used for navigation is called the (5) line. 5.

4. Any material is said to be (6) 6. when it is attracted by a magnet.

5. The compass used in an airplane is corrected for (7) due to the nearness of magnetic 7. substances and electric currents found in the airplane.

6. Soft iron becomes a magnet when near a magnet, due to (8). 8.

PART A (Continued)

7. The property of a material, such as soft iron, to be easily magnetized or demagnetized is called (9).

9.

8. The property of a material, such as hard steel, to resist being magnetized or demagnetized is called (10).

10.

9. When a magnet has reached its limit of magnetization it is said to be (11).

11.

10. The path an independent N-pole of a magnet would take in going from an N-pole to a S-pole of a magnet is called a (12).

12.

11. A magnetic field is composed of magnetic (13).

13.

12. The strength of a magnet may be affected by (14) and (15).

14.

15.

13. The angle between a meridian and the direction of the needle in a magnetic compass is called the angle of (16).

16.

14. Lines connecting points having the same declination are called (17) lines.

17.

15. If the angle of deviation is west it is (18) to the magnetic course to give the (19) course.

18.

16. The bottom end of a steel flagpole in the Northern hemisphere is a (20) pole.

20.

PART B

Select the word or group of words that correctly completes the meaning in each sentence. Place in the parentheses at the right the numbers immediately preceding the word or group of words selected.

1. When a piece of amber is rubbed with a cat's fur the amber (1) is charged negatively, (2) is charged positively, (3) is not charged. 1. () ✓

✓ 2. The electron carries a (1) positive charge, (2) neutral charge, (3) negative charge. 2. () ✓

✓ 3. The massive part of an atom is the (1) electron, (2) proton, (3) nucleus. 3. ()

✓ 4. An instrument that is used to detect and electric charge upon a body is known as (1) an ammeter, (2) a galvanometer, (3) an electroscope. 4. ()

✓ 5. The electrons are held strongly in the atoms by the attraction of the nucleus, and can not be moved easily in (1) a good conductor, (2) a good insulator, (3) acids. 5. ()

6. The speed of an electric current is (1) greater than, (2) less than, (3) equal to the speed of the electrons that compose it. 6. ()

✓ 7. A charge produced by (1) induction, (2) conduction is always opposite to the charge that induced it. 7. () ✓

8. The electrical density on a body is the greatest where the degree of curvature is (1) smallest, (2) greatest, (3) zero. 8. ()

9. Like charges (1) attract, (2) repel, (3) neither attract nor repel. 9. ()

10. The safest place in an electrical storm is (1) under a tall lone tree, (2) in the open, (3) in a steel framed building. 10. ()

11. The charge on one electron is called (1) a volt, (2) an elementary charge, (3) an electrostatic unit. 11. ()

✓ 12. A coulomb is a unit of (1) potential, (2) current of electricity, (3) quantity of electricity. 12. ()

✓ 13. The ampere is a unit of (1) potential, (2) quantity of electricity, (3) current of electricity. 13. ()

✓ 14. The volt is a unit of (1) potential difference, (2) capacitance, (3) current of electricity. 14. ()

15. A volt meter is an instrument used to measure (1) current, (2) quantity of electricity, (3) potential difference. 15. ()

2. The second part of the document addresses the issue of budgeting and financial planning. It provides a detailed overview of the budgeting process, from the initial identification of needs to the final approval of the budget. This section also includes a discussion on how to monitor and control the budget throughout the year, as well as strategies for managing any variances that may arise.

3. The third part of the document focuses on the management of assets and liabilities. It describes the various methods used to value assets and liabilities, and provides guidance on how to properly record and report these values. This section also discusses the importance of regularly reviewing and updating the asset and liability statements to ensure they remain accurate and up-to-date.

4. The fourth part of the document deals with the management of cash and other liquid assets. It outlines the procedures for cash management, including the use of cash flow statements and the implementation of cash control systems. This section also discusses the importance of maintaining adequate liquidity to meet the organization's needs, and provides advice on how to manage any cash shortages or surpluses.

5. The fifth part of the document discusses the management of debt and other financial obligations. It provides a detailed overview of the various types of debt, including bank loans, bonds, and other forms of financing. This section also discusses the importance of carefully managing debt, including the need to regularly review and update the debt schedule, and provides advice on how to negotiate and manage any debt restructurings.

6. The sixth part of the document focuses on the management of investments and other long-term assets. It describes the various methods used to value investments and other long-term assets, and provides guidance on how to properly record and report these values. This section also discusses the importance of regularly reviewing and updating the investment and other long-term asset statements to ensure they remain accurate and up-to-date.

7. The seventh part of the document discusses the management of taxes and other financial obligations. It provides a detailed overview of the various types of taxes, including income taxes, corporate taxes, and other forms of taxation. This section also discusses the importance of carefully managing taxes, including the need to regularly review and update the tax schedule, and provides advice on how to negotiate and manage any tax restructurings.

8. The eighth part of the document focuses on the management of other financial obligations, including the management of pension plans, profit-sharing plans, and other forms of employee compensation. It describes the various methods used to value these obligations, and provides guidance on how to properly record and report these values. This section also discusses the importance of regularly reviewing and updating the statements for these obligations to ensure they remain accurate and up-to-date.

9. The ninth part of the document discusses the management of other financial obligations, including the management of insurance, bonds, and other forms of financing. It provides a detailed overview of the various types of obligations, and provides guidance on how to properly record and report these values. This section also discusses the importance of regularly reviewing and updating the statements for these obligations to ensure they remain accurate and up-to-date.

10. The tenth part of the document focuses on the management of other financial obligations, including the management of other forms of financing, such as the management of the organization's credit rating. It describes the various methods used to value these obligations, and provides guidance on how to properly record and report these values. This section also discusses the importance of regularly reviewing and updating the statements for these obligations to ensure they remain accurate and up-to-date.

PART C

Opposite each group of words in the second column write in each pair of parentheses the number of the item in the first column which best completes the meaning. It is possible for an item to be used more than once.

- | | | |
|-------------------|-------------------------------------|--------|
| 1. alternating | 1. Name given to the electromotive | |
| 2. armature | force set-up when a conductor moves | |
| 3. armature drop | in a magnetic field. | 1. () |
| 4. brushes | 2. Name of an American who dis- | |
| 5. compound wound | covered simultaneously with an | |
| 6. commutator | Englishman that an electromotive | |
| 7. cut out | force is set up when a conductor | |
| 8. dynamo | cuts lines of force. | 2. () |
| 9. eddy | 3. Name of an Englishman who | |
| 10. Edison | discovered simultaneously with | |
| 11. Faraday | an American that an electro- | |
| 12. Franklin | motive force is set up when a | |
| 13. Fleming | conductor cuts lines of force. | 3. () |
| 14. generator | 4. Name of a scientist who | |
| 15. Henry | announced a law that states the | |
| 16. induced emf | relative of the direction of the | |
| 17. Lenz | magnetic field, the direction of | |
| 18. magneto | the conductor, and the direction | |
| 19. series wound | of the induced current. | 4. () |

PART C (continued)

20. shunt wound 5. Name of a scientist who
 21. tachometer established a convenient rule
 (electric) which involves the use of the
 22. terminal hand to determine the direction
 voltage of an induced current. 5. ()
6. A machine that changes
 mechanical energy into electri-
 cal energy but does not change
 electrical energy into mechanical
 energy. 6. ()
7. The part of a direct-current
 generator that rotates. 7. ()
8. The kind of currents that
 laminated cores of an armature
 tend to reduce. 8. ()
9. The kind of current that is
 always present in a rotative
 armature. 9. ()
10. The part of a direct-current
 generator that changes the
 current induced in the armature
 to a direct current in the line. 10. ()

Introduction

The purpose of this study is to investigate the effects of various factors on the growth and development of the human body. The study will focus on the relationship between nutrition, exercise, and the overall health of the individual.

The study will be conducted over a period of six months, during which time the participants will be monitored for changes in their physical and mental health.

The study will involve a series of experiments, each designed to test a specific hypothesis. The results of these experiments will be used to draw conclusions about the effects of the various factors on the human body.

The study will be conducted in a controlled environment, and the participants will be provided with all the necessary information and support throughout the process.

The study will be conducted in a series of steps, each of which will be designed to test a specific hypothesis. The results of these experiments will be used to draw conclusions about the effects of the various factors on the human body.

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PART C (continued)

11. An electric generator that has a permanent magnet in the field. 11. ()
12. Depends upon the rate of cutting lines for force. 12. ()
13. The voltage used in overcoming the resistance of an armature of a generator. 13. ()
14. A generator that has its armature and field connected in parallel. 14. ()
15. A generator that has its armature and field connected in series. 15. ()
16. The part of the generating system of an airplane that prevents the storage battery from discharging back through the generator. 16. ()
17. An instrument used in an airplane that depends upon a generator for indicating the r.p.m. of the propeller. 17. ()
18. A generator in which the

PART C (continued)

armature and the field are
connected both in series and in
parallel. 19. ()

19. The part of a generator
that takes the current off of
the armature. 19. ()

20. The name given to either
a generator or a motor. 20. ()

PART D

Select the correct answers and write them on the line which is numbered the same as the question.

1. What is the resistance of 5 - 50 ohms lamps connected in series? 250, 10, 55, 45, 100 1. ____ ohms
2. What is the resistance of 1000 feet of copper wire, .001 inch in diameter? 2600, 260, 26000, 5200, 1040 2. ____ ohms
3. The specific resistance of copper is 10.4. What is the resistance of 1000 feet of copper wire .001 inch in diameter? 1040, 104, .0104, 10,400 3. ____ ohms
4. What voltage will produce a current of 1.2 amperes thru 60 ohms resistance? 72, 61.2, 50, 52.2, 60 4. ____ volts
5. What resistance allows just .001 ampere to flow from a 1.5 volt dry cell? 150, 1500, 15000, .15, .015 5. ____ ohms
6. What current flows thru a lamp with 100 ohms resistance when only 5 volts is applied? 0.5, 100, 500, 20, 0.05 6. ____ amperes
7. Find the current through 5 ohms resistance when 110 volts are applied. 550, 11, 22, 115, 5 7. ____ amperes

PART D (continued)

8. What current flows thru .06 ohms resistance when a 6 volt storage battery is connected to it? 6.06, 100, .36, .01, 5.94 8. _____ amperes

9. What current will a 30 volt generator send thru a 1 ohm resistance? 30, 1, 31, 29, 7 9. _____ amperes

10. What resistance will allow only 0.1 ampere to flow from a 110 volt line? 11, 1100, 11.0, 1211, 9.01 10. _____ ohms

PART E

Place a plus sign (+) after each conclusion which is true and a zero (0) after each conclusion which is false.

I Permanent magnets:

1. Withstand mechanical shock and heating without loss of strength 1. _____
2. Are used in telephone receivers 2. _____
3. Are a part of every magneto 3. _____
4. Form an important part of many electrical instruments 4. _____
5. Can be used for years with little loss of strength 5. _____

II Magnetic reluctance is:

6. The opposite of magnetic permeability 6. _____
7. The measure of the resistance which a subject offers to magnetic lines of force 7. _____
8. Low in permalloy 8. _____
9. High in copper 9. _____
10. Greater in iron than in air 10. _____

III A piece of soft iron near a magnet:

11. Becomes magnetized by induction 11. _____
12. Is no longer magnetized very strongly when the original magnet is removed 12. _____

PART E (continued)

13. Has the near pole induced opposite to the sign of the inducing pole 13. _____
14. Is repelled from the magnet 14. _____
15. Is not magnetized 15. _____

IV The lines of force about a bar magnet:

16. Act as if they were stretched elastic 16. _____
17. Are as a whole called the field of force 17. _____
18. Cross one another 18. _____
19. Easily crowd into iron 19. _____
20. Penetrate glass 20. _____

V The N magnetic pole of the earth:

21. Does not coincide with the N geographic pole 21. _____
22. Slowly changes its location 22. _____
23. Has S - magnetism 23. _____
24. Is not quite opposite the S magnetic pole 24. _____
25. Is a location where the dipping needle has a minimum dip 25. _____

VI Magnetic declination:

26. Is the angle between the horizontal and the dip of a magnetic compass needle 26. _____
27. Is W in eastern United States 27. _____

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1.98	Physical Organizational Management	98
1.99	Mathematical Human Resource Management	99
1.100	Physical Human Resource Management	100

PART E (continued)

28. Is E in western United States 28. _____
29. May be 0^0 in some places 29. _____
30. Lines run in general N-S on a map 30. _____

VI The pocket compass:

31. Is used by mariners in a somewhat
different form 31. _____
32. Is affected by nearby masses of iron 32. _____
33. Points along a N-S magnetic line of
the earth 33. _____

KEY

PARTS

A	B	C
1. repel	1. (1)	1. (16)
2. attract	2. (3)	2. (15)
3. strength	3. (2)	3. (11)
4. distance	4. (4)	4. (17)
5. lubber	5. (2)	5. (13)
6. magnetic	6. (1)	6. (14)
7. deviation	7. (1)	7. (2)
8. retentively	8. (2)	8. (3)
9. magnetic induction	9. (2)	9. (1)
10. permeability	10. (3)	10. (6)
11. saturated	11. (2)	11. (12)
12. line of force	12. (2)	12. (10)
13. lines of force	12. (2)	12. (3)
14. heat	14. (1)	14. (20)
15. jars	15. (2)	15. (19)
16. declination or variation		16. (7)
17. isogonic		17. (21)
18. added		18. (5)
19. compass		19. (4)
20. North		20. (2)

KEY

D	PART	
	E	
1. 250 ohms	1. 0	12. 0
2. 2600 ohms	2. /	13. /
3. 10,400 ohms	3. /	20. /
4. 72 volts	4. /	21. /
5. 1500 ohms	5. /	22. /
6. .05 amperes	6. /	23. /
7. 22 amperes	7. /	24. /
8. 100 amperes	8. /	25. 0
9. 30 amperes	9. /	26. 0
10. 1100 ohms	10. 0	27. /
	11. /	28. /
	12. /	29. /
	13. /	30. /
	14. 0	31. /
	15. 0	32. /
	16. /	33. /
	17. /	

CHAPTER III

CLASSROOM PRESENTATION AND EVALUATION OF THE UNIT

Method of Instruction. Each assigned activity from the study and activity guide was discussed with the class by means of board work and experiment in considerable detail. Many of the core activities were explained and demonstrated by individual members of the class. In many instances the work of these pupils were supplemented by other members of the class and the instructor. Members of the class took notes on points brought out during these discussions which they had not obtained in their own reference study.

Each pupil was expected to keep a loose-leaf notebook in which he wrote down notes on the class discussions and the answers to questions on the guide sheets.

An objective test consisting of ninety-eight items was given first as a pre-test and again as a final test.

Daily log of the unit.

Date
1940

March 9 The instructor introduced the unit with a talk, demonstrations, and discussion centered around the following:

- (1) What causes or produces electricity?
- (2) What does electricity consist of?

- (3) What are the characteristics of electricity?
- (4) What is the difference between positive and negative electricity, and statical and dynamical electricity?
- (5) What are magnets? Where are magnets found?
- (6) In what way or ways are magnetism and electricity related?

During the latter part of the period a sixteen-millimeter film What is Electricity was shown to the group. The reactions of the pupils indicated that their interest had been keenly stimulated and that they were anxious to gain more information on magnetism and electricity.

March 10 The pre-test was administered during this period after a brief explanation as to the nature and purpose of such a test. The writer explained that this test was being given to measure any knowledge that the class might already have on magnetism and electricity. He pointed out that they might recall some facts from their course in general science, and that they might have some understanding of the subject from their general knowledge.

March 11 Items one, two and three of the study guide were discussed and demonstrated by members of the class. The response and interest were surprising to the instructor. Several members of the class had obtained considerable information. Members of the class took notes, without being prompted, on information which they had not obtained. Some of the members of the class were interested as to where this information had been obtained.

March 14 Many of the boys are currently interested in the Navy, and the compass and ships in general stimulated a lively discussion. The gyroscope and its application to the compass was demonstrated and discussed by one of the pupils with very little aid from the instructor.

March 15 Various types of mathematical problems connected with this work were presented, discussed and solved by the pupils during this period. The mathematics department reported that several pupils had checked with them on types of mathematical problems. (This item was included by the writer because he has been quite concerned about the teaching of physics in the eleventh grade. He has found that pupils of this grade have a very limited

knowledge of the metric system, graphs, interpolation, and other mathematical functions. The administrators of this high school have agreed to make a change for this reason, and in the future Physics will be a twelfth grade subject in this school.

March 16 The students were divided into six groups. (Grouping was arranged by seating plan. There are six tables in this classroom, as indicated by the floor plan found on page *nine* of this paper.) A chairman was appointed for each group by the instructor, and the groups were free to work on the items which they desired. The instructor moved about the room and sat in on some of the group conferences.

The students reacted well to this method, but with six groups working in this manner the room was rather noisy.

March 17 The plan of the previous day was continued with new chairmen being appointed by the instructor.

The pupils worked very well together and it was noted that there was less noise and confusion than on the previous day.

March 18 Group conferences were continued with very favorable results.

March 21 Some of the groups indicated that they had just about completed the study guide.

March 22 Pupils who had completed the activities on their study guide, sixteen in number, examined the optional related activities and began to work on the same. The other nine pupils, two groups, continued to work on the study guide and completed this work during this period.

March 23 All pupils worked on optional related
March 24 activities. It was interesting to see how
March 25 they "teamed-up" and how well they worked
March 26 together.

During these four days work was occasionally interrupted for reports by pupils in connection with these activities, and for general comments by the instructor relative to certain aspects of this work.

March 29 The final test was administered during this period and the pupils filled out questionnaires as to the value of this method.

DISCUSSION AND EVALUATION

Observations on the reaction of the class to the unit.

As stated before, the class consisted of twenty-five members of the college course. They had such high intelligence quotients and general ability that they could be expected to do good work. Their interest in the class activities was commendable, and they were most apt in self-expression. This group worked at such a high rate of speed that it would seem wise in the preparation of a future unit to include more core activities and more optional and related activities.

The pre-test and final test. The pre-test was the same as the final test in this case, but the pupils did not know that this was to be so. The results showed that the pupils had some general knowledge of these topics at the beginning of their study of the unit, as would be expected from their course in general science. The test on this unit contained ninety-eight items.

The scores on the final test showed noticeable improvement over the scores on the pre-test. (See Table V).

It will be noted that the distributions obtained on the following pages do not follow the so-called normal distribution. It would seem that the test prepared for this unit lacks validity and that the items should be more finely divided. One might expect better results by analyzing this test and revising

or discarding non-discriminative and otherwise defective items. It will also be of help when the number of pupils taking this test increases from semester to semester or from year to year.

In any event, even though the relative-growth groups varied considerably from a normal distribution, this information was valuable to the writer as a first step. No pre test, even though objective in nature, can supply all the evidence needed. In an attempt to supplement the information obtained from the final test, the following was also given consideration:

1. Consideration of pupil gain (Final test minus pre-test)
2. Careful observation
3. Oral questioning
4. Consideration of written work passed in in connection with this work

It is the intention of the writer to go one step further when this unit is next taught, and to require a written summary of the unit, which will be an essay-type examination. This examination will be objectified by direct comparison with the statement of the unit, its delimitation, and the list of indirect and incidental learning products.

TABLE II
CALCULATION OF STANDARD DEVIATION ON PRE-TEST

Scores	Difference	Difference ²
55	21	441
54	20	400
52	18	324
44	10	100
39	5	25
36	2	4
36	2	4
36	2	4
36	2	4
36	2	4
36	2	4
35	1	1
35	1	1
33	1	1
30	4	16
29	5	25
28	6	36
28	6	36
28	6	36
28	6	36
28	6	36
25	9	81
24	10	100
14	20	400
<u>545</u>		<u>2215</u>

Mean = 34

$$\text{Sigma} = \sqrt{\frac{2215}{25}} = 9.4$$

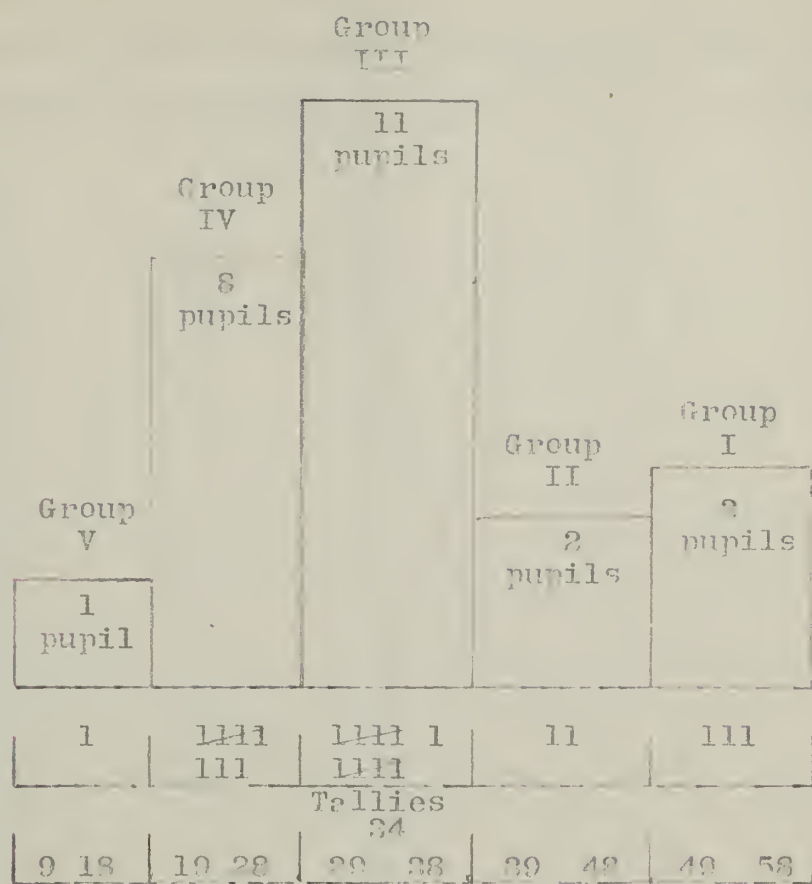


Figure VI. Distribution of pupils on pre-test

TABLE III

CALCULATION OF STANDARD DEVIATION ON FINAL TEST

Scores	Difference	Difference ²
85	27	729
80	22	484
73	15	225
72	14	196
63	5	25
62	4	16
62	4	16
62	4	16
60	2	4
60	2	4
59	1	1
57	1	1
57	1	1
55	3	9
54	4	16
54	4	16
53	5	25
52	6	36
51	7	49
51	7	49
49	9	81
49	9	81
48	10	100
45	13	169
43	15	225
1456		2584

Mean = 58.24

$$\text{Sigma} = \sqrt{\frac{2574}{25}} = 10.12$$

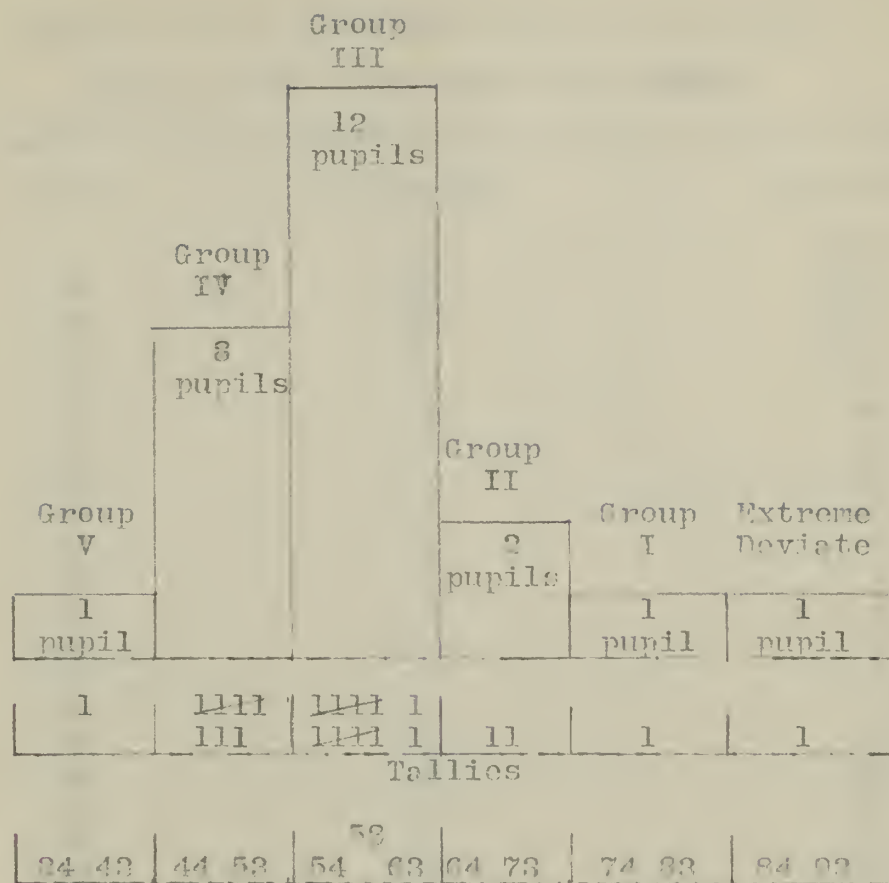


Figure VII. Distribution of pupils on final test

TABLE IV
CALCULATION OF STANDARD DEVIATION ON GAIN
(FINAL TEST MINUS PRE-TEST SCORE)

Scores	Difference	Difference ²
43	19	361
42	18	324
41	17	289
34	10	100
33	9	81
32	8	64
30	5	25
28	4	16
28	4	16
26	2	4
25	1	1
25	1	1
21	3	9
21	3	9
21	3	9
19	5	25
19	5	25
18	6	36
18	6	36
17	7	49
16	8	64
15	9	81
15	9	81
13	11	121
12	12	144
<u>611</u>		<u>1971</u>

Mean = 24.45

$$\text{Sigma} = \sqrt{\frac{1971}{25}} = 7.8$$

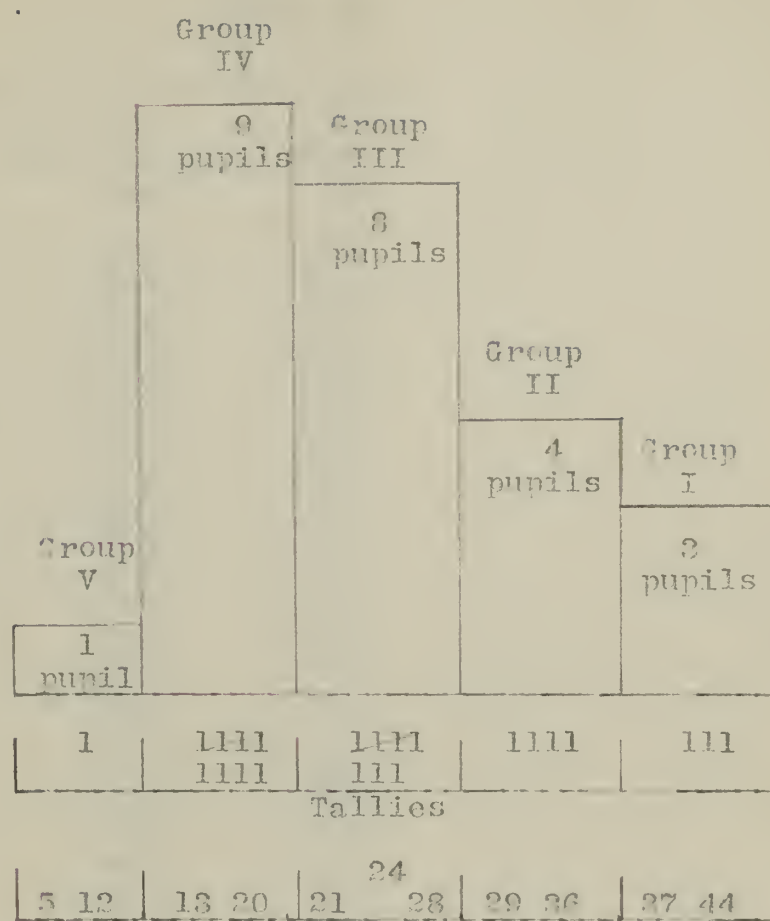


Figure VII. Distribution of pupils on gain

TABLE VIII
PUPIL STATISTICS

Pupil	Sex	Chronological	Mental	Intelligence	Pre-test	Final	Gain	Objective	Careful					All
		Age	Age	Quotient					Test	Test	Gain	Questioning	Written	
A	F	16-5	18-1	110	28.	53	25.	IV	III	III	II	III	III	III
B	M	16-5	18	109	22.	45	17.	IV	IV	IV	V	IV	IV	IV
C	M	16-8	19-4	116	28.	62	34.	III	II	I	II	II	II	II
D	M	15-11	19-1	120	36.	55	19.	III	IV	II	II	III	III	III
E	M	16-6	18-7	113	28.	60	32.	III	II	III	III	III	III	III
F	M	15-11	18-4	116	54.	72	18.	II	IV	II	II	II	II	II
G	M	16-2	16-4	101	36.	51	15.	IV	IV	III	IV	III	IV	IV
H	F	16-7	22-9	137	35.	63	22.	II	II	I	II	I	II	II
I	M	15-10	17-1	108	29.	62	33.	III	II	I	II	II	II	II
J	F	16-2	19-9	122	20	62	42.	III	I	I	I	I	I	I
K	F	16-4	21-3	131	36.	52	16.	IV	IV	III	IV	IV	IV	IV
L	M	15-11	17-7	111	21.	49	15.	V	IV	V	IV	IV	IV	IV
M	F	16-9	18-6	110	35.	54	19.	III	III	II	III	II	III	III
N	M	15-6	17-4	112	36.	48	12	IV	V	V	IV	IV	IV	IV
O	M	16-1	19-2	120	23.	54	21.	III	III	II	II	II	II	II
P	M	15-8	23-4	147	44.	35	41.	I	I	I	I	I	I	I
Q	M	15-3	20-7	135	39.	60	21.	III	III	II	III	III	III	III
R	F	16-9	22-7	141	55.	73	18.	I	IV	III	II	II	II	II
S	M	16-2	16-	89	25.	51	26.	IV	III	IV	IV	IV	IV	IV
T	M	16-8	16-3	98	14	57	43.	III	I	II	I	II	II	II
U	F	15-9	17-6	112	26.	49	13	IV	IV	IV	IV	V	IV	IV
V	F	15-11	19-9	118	24.	49	25.	IV	III	III	IV	IV	IV	IV
W	M	15-10	19-2	121	36.	57	21.	III	III	II	III	III	III	III
X	M	16-6	17-2	104	36.	59	22.	III	II	III	III	III	III	III
Y	M	16-	22-	133	52.	80	28.	I	II	I	I	I	I	I

Pupil evaluation of methods and topics. In order to get the reaction of the pupils to some of the methods and topics used in teaching this unit, a check list was prepared and submitted to the pupils. Each pupil was asked to indicate by a plus sign (+) that he found a particular method or topic "liked", "easy" or "helpful"; by a minus sign (-) that he found it "disliked", "difficult", or "useless"; and by a zero (0) that he regarded it as indifferent. The results are shown in Tables VI and VII. For purposes of comparison, the papers were scored by allowing + 1 for each plus sign, - 1 for each minus sign, and 0 for each zero. A total score of twenty-five on an item would indicate that all twenty-five pupils regarded this item with favor.

The data shows that the pupils liked and profited by all phases and aspects of the unit method. Although it is impossible to draw valid conclusions from the study of so few cases, it does not appear that there are any serious deficiencies in the methods or materials used.

The writer must admit, however, that, although he was aware of the fact that each optional related activity should be a little study guide in itself, those contained in this paper were lacking in sufficient detail. This was evidenced by the fact that several of the pupils came to the instructor and asked what they should do next or where they might obtain information pertaining to some particular phase of the activity which they were following. A revision of these optional related activities

TABLE VI
PUPIL EVALUATION OF TEACHING METHODS

	Liked or Disliked	Easy or Difficult	Helpful or Useless
Talks by teacher	14	10	20
Written answers to questions	10	-6	16
Teacher demonstrations	23	20	22
Pupil demonstrations	20	16	13
Discussion of questions	18	17	19
Written reports on experiments	12	10	16
Class study periods	17	20	15
Optional topics	24	11	22
Recitations	6	8	12
Notes made in class	16	6	12

TABLE VII

PUPIL EVALUATION OF TOPICS IN UNIT

	Liked or Disliked	Easy or Difficult	Helpful or Useless
Natural, permanent, and temporary magnets	22	18	19
Repulsion and attraction	24	14	17
Earth as a magnet	20	22	20
Historical topics	23	22	16
Magnetic induction	17	18	14
Permeability and reluctance	12	13	13
Theory of magnetism	20	17	19
Gyro-compass	24	16	20
Electron theory	19	12	17
Lines of force	21	20	19
Theory of electricity	16	12	14
Comparison of magnetism and electricity	19	21	23
Related mathematics	18	11	16
Electric bell	24	19	22
Telegraph circuit	22	16	17
Direction of flow of current	17	13	16
Electrical resistance	16	12	18
Electrical measuring instruments	20	16	18

should be undertaken before this unit is used again.

Twenty-one of the pupils indicated that they preferred the unit method to the traditional method of instruction; the other four seemed to be unable to adjust themselves to the new situation created by the unit method of instruction,

Conclusion. The method of the unit assignment is much superior to the old daily assignment procedure with this type of class. The pupils showed more interest and seemed to gain a better perspective of the field being studied.

The number of topics in the study guide and optional and related activities should be increased for a group with this amount of ability. The study guide should, of course, be revised frequently to keep it up to date and to shift the emphasis according to the progress of science and the needs of the class.

The organization here proposed proved to be satisfactory and worthy of a further and more extended study with classes of various levels.

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